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MSFC-STD-481
December 30, 1966

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

STANDARD

RADIOGRAPHIC INSPECTION AND ACCEPTANCE

STANDARDS FOR FUSION-WELDED JOINTS.

IN STAINLESS AND HEAT-RESISTANT STEEL

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December 30, 1966

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Standard

Radiographic Inspection and Acceptance Standards for Fusion-Welded Joints in Stainless and Heat-Resistant Steel

MSFC-STD-481

1. This standard, dated December 30, 1966, and prepared by the George C. Marshall Space Flight Center has been approved and is available for use by MSFC and associated contractors.

2. All recommended changes shall be submitted to the Engineering Specifications and Standards Section, Propulsion and Vehicle Engineering Laboratory (R-P&VE-VNR) for coordination with the cognizant design activity.

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STANDARD

RADIOGRAPHIC INSPECTION AND ACCEPTANCE

STANDARDS FOR FUSION-WELDED JOINTS

IN STAINLESS AND HEAT-RESISTANT STEEL

1. SCOPE

1.1 Scope. - This standard establishes the radiographic inspection and acceptance standards for fusion welded joints in stainless and heat-resistant steel.

1.2 Application. - This standard covers the quality requirements for fusion welded joints in stainless and heat-resistant, steel-space, vehicle components less than 0.250 inch in thickness, such as flexible ducts and connector tubes, and the procedures for radiographic inspection to determine acceptability.

1.3 Limitations. - Where weld quality exceeding the radiographic acceptance limits specified in this standard is required, the limitations will be specified in the contract or the applicable drawing. Where special equipment is required, the special requirements will be specified in the contract or the applicable drawing.

2. REFERENCED DOCUMENTS

2.1 The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply.

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STANDARDS

Military

MIL-STD-453 Inspection, Radiographic.

George C. Marshall Space Flight Center

MSFC-STD-397 Radiographic Laboratory
Qualification.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 Lack of fusion. - Lack of fusion is defined as a condition in which one or more interfaces of the parts being welded and the weld bead are not completely fused.

3.2 Insufficient penetration. - Insufficient penetration is defined as a condition where the fusion does not extend into the root of the joint, especially as pertaining to the configuration of fillet welds.

3.3 Metal thinning and undercutting. - Metal thinning is defined as a condition which exists when the weld or adjacent area, whether weld metal or parent metal or a combination of both, is thinner than the original wall thickness. Undercutting is defined as a condition characterized by sharp notches or stress risers in the vicinity of the fusion joint between the weld bead and the parent metal.

3.4 Surface irregularities. - Surface irregularities in the weld area are defined as workmanship defects resulting in tool marks, die scores, and scratches.

3.5 Inclusions. - More dense inclusions are usually present in the form of tungsten from the welding electrode. Less dense inclusions are generally impurities resulting from poor cleaning or improper shielding of gas mixtures.

3.6 Linear porosity. - Linear porosity is defined as a condition in which three or more cavities or voids may be connected with a straight line whose length is less than one and one half times the thickness of the thinner parent metal.

4. GENERAL REQUIREMENTS

4.1 Qualification. - Radiographic equipment, laboratory facilities, and procedures for qualification shall conform to Standard MSFC-STD-397.

4.2 Equipment.

4.2.1 Focal spot. - All radiographs shall be made using X-rays having a tube with a focal spot not greater than 2.5 millimeters.

4.2.2 Penetrameters. - Unless otherwise specified by the procuring activity, penetrameters used in radiographic processes shall be in accordance with Standard MIL-STD-453.

4.2.3 Viewers. - Unless otherwise specified by the procuring activity, a commercial film viewer shall be used. When necessary, 5X to 7X magnification may be used to examine critical areas.

4.3 Materials. - The film used for producing radiographs shall be an acceptable safety film. Kodak Industrial X-ray film, type M and type AA, or approved equal, are acceptable for radiographic inspection of fusion welds described herein.

4.3.1 Film densities. - Film densities recommended for the type welds covered by this standard are as follows:

- (a) Straight wall tubing - 1.75 to 2.25.
- (b) Corrugated sections - 1.50 to 1.85.
- (c) All other sections - 1.75 to 2.25.

4.4 Soundness requirements of fusion welds.

4.4.1 Cracks. - Any transverse or longitudinal crack in the weld bead or the base metal shall be unacceptable.

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4.4.2 Fusion. - Lack of fusion (see 3.1) of the base metal and the weld bead shall be unacceptable.

4.4.3 Penetration. - Unless otherwise specified on the applicable drawing, insufficient penetration (see 3.2) shall be unacceptable. This defect is common to a fillet-type weld and is identified by a dark wavy band on the radiograph (see figure 1).

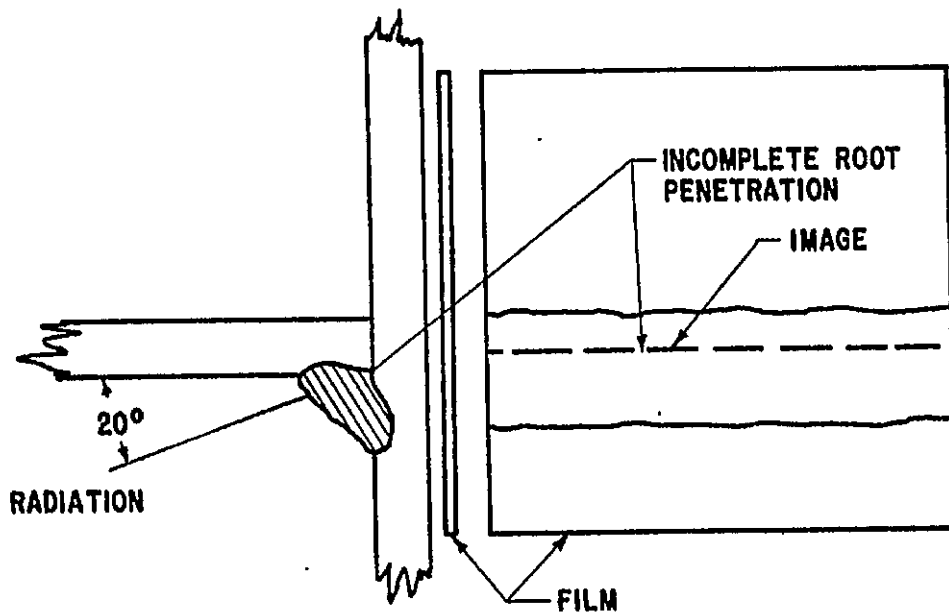


Figure 1. Example of lack of penetration.

NOTE

A similar image can be caused by insufficient fusion or undercutting. However, these defects can normally be distinguished by their location on the image.

4.4.4 Metal thinning and undercutting. - Metal thinning and undercutting (see 3.3) shall be unacceptable under the following conditions:

- (a) When sharp notches, which act as stress risers, occur in the vicinity of the weld.
- (b) When gradual transition thinning in excess of 10 percent of the original parent metal thickness occurs in the vicinity of the weld.

4.4.5 Cavities.

4.4.5.1 Sharp cavities. - All cavities characterized by sharp angles shall be unacceptable (see figure 2).

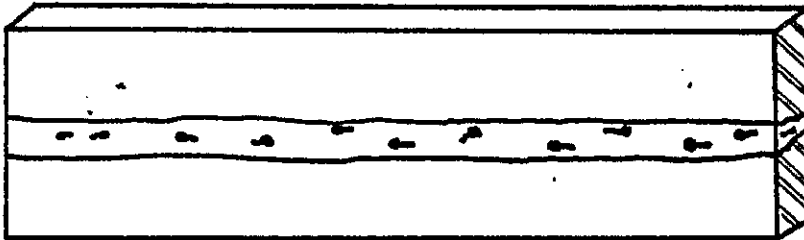


Figure 2. Example of sharp angle cavities.

4.4.5.2 Isolated or scattered cavities or voids.

4.4.5.2.1 Butt-welded joint. - Isolated or scattered cavities or voids having a diameter in excess of 20 percent of the thinner parent metal thickness shall be unacceptable in a butt-welded joint.

4.4.5.2.2 Lap-welded joint. - Isolated or scattered cavities or voids having a diameter in excess of 30 percent of the thinner parent metal thickness shall be unacceptable in a lap-welded joint.

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4.4.5.3 Linear porosity. - When a group of voids or cavities comprise linear porosity (see 3.6), the summation of the diameters of those voids or cavities in any linear inch of a weld that exceeds 20 percent of the nominal parent metal thickness shall be unacceptable.

4.4.6 Surface irregularities. - Excessive surface irregularities (see 3.4) in the weld or adjacent area shall be unacceptable.

4.4.7 Inclusions. - More dense and less dense inclusions (see 3.5) shall be regarded as cavities and graded as such (see 4.4.5.2.1, 4.4.5.2.2, and 4.4.5.3).

4.5 Identification marking.

4.5.1 Test area. - Test areas shall be clearly identified and assigned assembly and radiographic serial numbers, letters, or a combination of numbers and letters. The markings shall be affixed to the sample with an ink stamp or electrolytic-etch process to obtain a permanent-type identification. Assemblies that require more than one radiograph for complete inspection coverage shall be identified by a series of numbers or letters to identify the test areas with specific radiographs.

4.5.2 Radiographic film identification. - Radiographic film shall be identified by the serial identification corresponding to the system utilized in 4.5.1. Lead letters or numbers or both shall be placed on the film to produce a permanent identification.

4.6 Extent of inspection. - Unless otherwise specified by the procuring activity, longitudinal and circumferential butt welds or fillet welds in stainless or heat-resistant steel shall be radiographed 100 percent. The component and test area shall be identified in accordance with 4.5.1.

4.7 Rejection. - Components which fail to meet the requirements of this specification shall be rejected. Unacceptable components shall be clearly identified and removed from acceptable production. Unless otherwise specified, disposition of radiographic film of defective assemblies shall be at the discretion of the contractor.

5. DETAILED REQUIREMENTS

5.1 Focal distance. - The maximum focal distance to obtain the sharpest definition possible for any type radiographic exposure shall be used. Unless otherwise specified by the procuring activity, the minimum focal distance shall be 36 inches.

5.2 Equipment. - Radiographic inspection to determine the quality of fusion welds shall be performed utilizing the equipment and techniques capable of indicating the presence of defects having any dimension equal to or greater than 2 percent of the thickness of the section being radiographed.

5.2.1 Radiographic technique. - The radiographic technique shall be adjudged correct when the image details of the penetrameter (see 4.2.2) are sharply defined in all radiographs of a given welded area.

5.3 Radiographic procedure. - Unless otherwise specified by the procuring activity, the radiographic procedure shall be as follows:

- (a) In a "safe light" area, load the radiographic film in a lightproof film holder.
- (b) Identify the test area and the corresponding film in accordance with 4.5.1 and 4.5.2.
- (c) Place the film as near the surface being radiographed as possible.
- (d) Place the penetrameter (see 4.2.2) adjacent to the surface being radiographed.
- (e) Radiograph the sample.
- (f) Process the film in accordance with the recommendations of the manufacturer of the film and the processing chemicals.

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- (g) Examine the film on a suitable viewer (see 4.2.3) for weld defects as specified in 4.4.1, 4.4.2, 4.4.3, 4.4.5.1, 4.4.5.2, 4.4.5.3, and 4.4.7.
- (h) X-ray the areas where radiographic interpretation is questionable and also in cases where the film possesses blemishes, water spots, or pressure marks.
- (i) Identify each acceptable assembly with an identification symbol or number.
- (j) Package properly identified radiographic film of acceptable assemblies, and ship the film to the procuring agency.

5.4 Surface defects. - The welded area shall be visually examined and the defective area measured by mechanical or optical means as required to determine conformance to 4.4.4 and 4.4.6.

5.5 Changes, deviations, or waivers. - No technical changes, deviations, or waivers will be made to the requirements of this document without the approval of the cognizant design engineering activity of MSFC. All changes, deviations, or waivers will be submitted to the Engineering Specifications and Standards Section, Propulsion and Vehicle Engineering Laboratory (R-P&VE-VNR) Huntsville, Alabama, for coordination with the cognizant design activity.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the

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MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

1. APPROVED PROJECT:	2. DOCUMENT/DRAWING NUMBER: <i>MSFC-STD-481</i>	3. CONTROL NUMBER:	4. RELEASE DATE: <i>12/30/66</i>	5. SUBMITTAL DATE:
6. DOCUMENT/DRAWING TITLE: <i>Radiographic Inspection and Acceptance Standards for Fusion-Welded Joints in Stainless and Heat-Resistant Steel</i>			7. REPORT TYPE:	
8. CONTRACT NUMBER / PERFORMING ACTIVITY:	9. DRD NUMBER:	10. DPD / DRL / IDRD NUMBER:		
11. DISPOSITION AUTHORITY (Check One) <input checked="" type="checkbox"/> Official Record - NRRS <i>8/12/1A</i> <input type="checkbox"/> Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed)	12. SUBMITTAL AUTHORITY:	13. RELEASING AUTHORITY: <i>MB Cook</i>		
14. SPECIAL INSTRUCTIONS:				
15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER:		16. ORIGINATING NASA CENTER:		
		17. OFFICE OF PRIMARY RESPONSIBILITY:		
18. PROGRAMMATIC CODE (5 DIGITS):			19. NUMBER OF PAGES:	

II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:
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III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE:	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:
30. ISSUE:	31. ANNEX:	32. SCN:	33. DCN:	34. AMENDMENT:	
35. APPENDIX:	36. ADDENDUM:	37. CCBD:	38. CODE ID:	39. IRN:	

IV. EXPORT AND DISTRIBUTION RESTRICTIONS

<input type="checkbox"/> Privacy Act (see MWI 1382.1) <input type="checkbox"/> Proprietary (see MPD 2210.1) <input type="checkbox"/> Patent (see MPG 2220.1) <input type="checkbox"/> ITAR (see MPG 2220.1)	<input type="checkbox"/> EAR (see MPG 2220.1) <input type="checkbox"/> Other ACI (see NPG 1620.1 and MPG 1600.1) _____ <input checked="" type="checkbox"/> No statutory or institutional restrictions applicable -- material may be electronically distributed to user in the NASA domain
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40. ORG. CODE: <i>ED32</i>	41. PHONE NUMBER: <i>544-9323</i>	42. NAME: <i>Linda Clark</i>	43. SIGNATURE/DATE: <i>Linda Clark 10/30/02</i>
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VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

44. RECEIVED BY: <i>Jammy Wise</i>	45. DATE RECEIVED: <i>10-15-03</i>	46. WORK ORDER:
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